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# Physics as a Mode of Wonder

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# PHYSICS AS A MODE OF WONDER

Donald Cowan

What is the state of physics today and where is it going? We could say first that all the sciences continue to draw closer together. Molecular Studies, for example, encompass physics, chemistry, and biology--each mode of seeing respecting the others, not only comparing each other's data but using them in analyses--much as thermodynamics was wont to do in days of yore. It seems likely that a phenomenological association in the sciences may replace or at least modify departmental segregation in academic institutions.

The twentieth century has belonged undoubtedly to physics. The nineteenth century had been an epoch of chemistry. In physics, it had closed with the triumph of electro-magnetic theory seemingly leaving nothing to be discovered but precision--the extension of decimal places. But the sky rockets and fire crackers celebrating the new twentieth century had not faded before the recognition of relativity and the advent of quantum theory opened a new age. World War I was still a chemist's war, but WWII was ruled by Physics, notably radar, ballistics, and THE BOMB. Peacetime, too, became a ward of physics with television, computers, and all sorts of new technologies made possible by chips and electronics.

At present, biology is where the action is most visible, moving with its genome in the last score of years from lore into a truly interceding science. Medical practice will be almost completely reorganized, with technology supplying arcane techniques in the manner of filling station pumps where the patient pulls up, inserts a credit card, selects a symptom, and gets a remedy--maybe reversing the 20th century

movement of medicine into specializations. Technology is the great equalizer.

Indeed, it may be time for all the disciplines to regather the clusters of thought that constitute their narratives.

In physics, we have become aware of a metaphysical aspect that considerably extends its application. The indeterminacy principle refutes any tendency toward rationalism. For that matter, so does determinacy, cause and effect quickly outstripping mechanics with its visualizable levers and gears. Rationality is a fragile pose to bear the weight of reality. We discover with relief the arbitrary status of reason. For example, "Two things cannot occupy the same place at the same time" must always have a coda--"unless they do." Truth, it seems, is not an argument. It simply <u>is</u>. Nonetheless, we physicists shamelessly employ the argument. We maintain that it is the business of physics to recognize truth and <u>make</u> it rational, and if we have to twist and torture reason and seemingly abandon it to make theory and experience congruent, so be it. Child of the enlightenment, physics was certain it could fit theory to reality at every point and accurately predict the fate of every particle. It can't. Only in bulk can reality present itself, statistically, holistically. Identity is exchangeable

If physics was at first measurement and precision, what did it become in its growth process? What is it today? Let's try a little parable--not too long--just to examine the kind of knowledge we gain from physics in our time.

We might begin--as the philosophers always say their discipline does--in wonder.

Why does matter hold together? Why don't all the constituent parts of an object disperse? It holds together because ENTITIES (small bits of stuff) cling together to form a communicating medium--that is, a medium in which information, or energy, can be exchanged.. They cling together because they lack sufficient energy to pull apart. In this situation each contributes exchange particles such as gluons or mesons to the common medium they help form--be it solid, liquid, or gas. These entities can regain this lost energy separately from some source--heat (as in vibrating),impact (as in sputtering), electricity (as in charging). Then the entity is freed from its medium, possibly to be captured by some other form--perhaps going from liquid to gas, as a vapor. If the energy regained comes from motion--1/2 mv2--then the layer of liquid that wets the bank stands still and each succesive layer slips along faster and faster until at some stage it all reaches a critical energy per particle, and turbulence sets in. All this motion and countermotion forms a little two-lane street of small whirlpools alternately turning clock-wise in one lane, counter clock-wise in the other. (We call it a Karmen Street, after the Brothers Karmen, who first studied the phenomenon.) From there on out to midstream the flow is turbulent with a high rate of mixing.

Any entity--let's call it a molecule--whose internal structure gains enough energy to match the release point jumps out of the medium--evaporates, we say-- and if all of the bound molecules jump out, each is free to go as it will; the result is chaos. That "release energy," incidentally, considered from the point of view of sound, is E equals m c squared, where m is the mass of the molecule and c is the velocity of sound in the medium. You might recognize the equation as itself an analog in sound of Einstein's formula $E=mc^{2,}$ where c in this instance is the speed of light, and E is the energy of creation that tears

a particle of mass m out of the void--*ex nihilo*--out of nothing. Actually it takes 2 $mc^2$ because creation has to occur in pairs--a particle and an anti-particle--an anti-particle so that the sum still adds up to nothing.

Well! I've never told it quite that way before, and I'm fairly certain no one else ever has because likely no one else has happened on the right analogy. Really, I just meant to set up an analogy for the Fellows of the Institute and I stumble onto a peak in Darien.

So, what is the analogy and what did I intend it for? The idea behind instituting this series of short talks by the Institute Fellows was to bind the fellows together by an exchage of outlooks toward the future from our various disciplines. The gain, then, would be a net gain in wisdom for us all. The exchange particles we toss into the common pot are ideas generated in the exercise of our disciplines; I contribute something from what I have thought up, written about, or read in the arcane literature of my calling, and I absorb something you in turn have set before us. This exchange binds us together. The field of communication in which we are immersed becomes richer with each contribution. It may be that the greatest contribution my discipline can supply is a ready reservoir of analogies.

How do we know the contribution we each make will be compatible with others? Your "particles" will have other "masses" than mine, other speeds of sound. We can't know. So we look to our analogies. What do they suggest? Well, it seems reasonable to suppose that whatever dissolves in the fluid will match the impedence it presents (to sound) to the impedence the other ingredients experience. Is that supposition true? We don't know. It's not in the scientific reports. So we postulate it; we pretend that it's true, then go on to see the

consequences--and there are many--about turbulence, chaos, electrolysis, fusion. photo-electric cells. Creation is so intermingled that if the web of knowing is plucked at one node all the other nodes in the whole web are shaken.

Of course we search the reports to seek as much data as possible so that we don't have to set up our own measuring apparatus. And when it's water we're working with, the information is mostly all there in tables of raw data just waiting to be interpreted. Water has been with us a long time, but there is a surprising amount of interesting information still hiding in the web.

What I have presented represents fairly well the way a physicist works. Isn't it more or less the way we all work? We all postulate, estimate, guess. We try to make it all look sensible. Perhaps we should redraw the web of thought that interconnects the nodes of knowing and reassign to the disciplines the requisite skills that activate meaning--an encyclopedic undertaking, true enough, but we who associate with academia may be compelled to begin it for the sake of our vocations.

There's lots for us to talk about. And it may be that chance analogies will generate creative thought in another discipline. Let's have more talk: it's one of the rarest of occupations in our time.